

BADCT GUIDANCE DOCUMENT
FOR
PRETREATMENT WITH OIL/WATER SEPARATORS

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Water Quality Division
Aquifer Protection Program

Introduction

A facility, which is required to obtain an Arizona Aquifer Protection Permit for a discharge which may impact an aquifer, must, in some cases, pretreat its effluent to remove oil and grease. For these facilities, pretreatment is one of the conditions necessary to meet the regulatory requirement to use the Best Available Demonstrated Control Technology (BADCT) to minimize the potential for groundwater contamination. This document outlines basic technical criteria for the evaluation of the use and design of oil/water separators as part of BADCT. Other related guidance documents are available from the Arizona Department of Environmental Quality (ADEQ) concerning BADCT and drywells.

Wastewaters Which May Require Pretreatment with Oil/Water Separators

Below is a partial listing of facilities and activities which are likely sources of oil contamination of wastewaters and stormwaters.

- Asphalt materials production
- Parking lots for businesses, churches, schools, apartments, recreational areas
- Airports
- Railroad yards
- Vehicle fueling and maintenance areas
- Cooling and heating blowdown
- Compressor station blowdown
- Car salvage facilities
- Truck stops
- Electric power generating facilities
- Petroleum production and distribution centers
- Metal working
- Food processing
- Vehicle washing

If the facility discharges wastewater or stormwater to the land surface or waters of the state, this discharge may be subject to federal, state, or local regulations governing surface water quality control. Additionally, if the facility discharges directly to an aquifer or to the land surface or the vadose zone in such a manner that the pollutant will reach an aquifer (A.R.S. §49.201.10), then Arizona's aquifer protection permit regulations may also apply, except as noted below:

- Facilities used solely for the management of stormwater and which have obtained a National Pollution Discharge Elimination System (NPDES) permit and have notified ADEQ, are authorized to operate under a general aquifer protection permit, in accordance with the conditions outlined in A.R.S. §49.245.01.
- In general, other commercial/industrial facilities, which discharge stormwater only into a drywell or impoundment, and the stormwater does not come into contact with active on-site areas, do not require an aquifer protection permit.

Treatment Objectives

Oil/water separators were in widespread use in industrial and commercial processes long before the era of environmental regulation. The original treatment objectives were practical and process-related, such as prevention of:

- Fouling of instruments and equipment.
- Interference with settling and other processes.
- Hazardous accumulations in equipment.

The levels of treatment required to meet these objectives typically are not as stringent as those necessary to meet environmental objectives, which are intended to protect aquatic life as well as human health, and broadly aimed to prevent degradation of water quality.

Performance Standards

Currently, for discharge to surface water, the NPDES new source performance standards set a discharge limit for oil and grease of 15 mg/l for most industry groups. This standard represents that level of control achievable by the Best Available Technology (BAT) for removal of oil and grease. Arizona's aquifer protection BADCT for oil and grease removal is effectively equivalent to the NPDES BAT. That is, BADCT for oil and grease removal is any control technology together with operation and maintenance procedures, which generate an oil and grease concentration in the effluent of 15 mg/l or less. Similar to the NPDES stormwater requirements, a completed pollution prevention plan is considered an essential component of BADCT. The performance standard is based on EPA draft method 1664-N-Hexane Extractable Material (HEM), EPA-821-B-94-004, January, 1995. Other equivalent methods approved by the Arizona Department of Health Services Laboratory are also acceptable.

BADCT Documentation

In proposing to use an oil/water separator as one component of BADCT, a facility must consider the following:

- Waste characterization
- Flow determination
- Separation capacity
- Other design elements
- Operation and maintenance
- Waste handling
- Maintenance
- Spill capacity
- Pollution Prevention Plan

Each topic is discussed in more detail below.

Waste Characterization

Oils and grease are present in process wastewater and stormwaters in one of five forms, as shown in Table 1.

For the purposes of environmental regulation, facilities can usually apply process knowledge, documented by MSDS sheets and process flow diagrams, to identify the type of oil contamination which may be present. Stormwater often contains droplets in the range of 25 to 60 microns and concentrations of oil and grease typically from about 4 mg/l to 50 mg/l.

These guidelines address only removal of free oil contamination. Emulsified and dissolved oil contamination require additional treatment. Removal of oil wet solids, to a greater or lesser extent, typically accompanies gravity oil separation and will only require additional pretreatment if the amount of particulate matter is likely to interfere with oil/water separation. Methods for the removal of emulsified and dissolved oils are listed as Attachment 1, but are not considered in detail in this document.

Table 1. Oil & Grease Contamination in Wastewater

FormFormation	
Free oil	Oil present in wastewater or stormwater as droplets 20 microns or larger, having little or no water associated with it. Floats to the surface because of its low specific gravity.
Physically emulsified	Oil dispersed in water in a stable form. Mechanical emulsions are formed by mixing through pumping, valves (especially globe valves), other restrictions in flow, vertical piping, and other means, and present as droplets 5 to 20 microns in size.
Chemically emulsified	Chemical emulsions are usually intentionally formed using detergents, alkaline fluids, or other reagents, and having a droplet size less than 5 microns.
Dissolved	Oil which is solubilized in the liquid solvent and must be detected using infrared analysis or other chemical means. Oil/water separators do not remove dissolved oil.
Oil wet solids	Oil that adheres to the surface of particulates materials.

Flow Determination

Facilities should provide piping diagrams showing all drainage into the oil/water separator with estimates of peak flow from each source. Sizing must be based on the combined peak flow rate into the unit.

Sizing of oil/water separators treating combined stormwater and process wastewater must be based on the sum of the process flow and the stormwater flow, as discussed in detail in Attachment 2.

The procedure to determine the additional capacity needed to contain spills for those oil/water separators located in areas where spills may occur is outlined below in the section addressing "Spill Capacity".

Separation Capacity

The oil/water separator must be suitably sized or designed to allow a retention time sufficient to yield an effluent with a concentration of oil and grease no greater than 15 mg/l. The actual dimensions of the unit required will depend not only upon the volume of flow requiring treatment and the size distribution of the free oil droplets present, but also upon the use of equalization tanks and corrugated plate designs and coalescers for enhanced separation.

Gravity separation of oil and water occurs, according to Stokes Law (see Attachment 2), because of the difference in specific gravity between water and immiscible oil droplets. Oil/water separators are basically liquid containment structures that provide a hydraulic retention time sufficient to allow globules to rise to the liquid surface and form a separate layer which can be removed by skimmers, pumping, or other methods. In general, the larger an oil droplet, the greater the buoyancy force it exerts and the faster it rises. Overall, the longer the retention time of liquid in the separator, the smaller size of oil droplet separating.

API Separators

Chapters 3 and 5 of the American Petroleum Institute (API) Manual on Disposal of Refinery Wastes (Volume on Liquid Wastes, Latest Edition) and API Bulletin No. 1630, first Edition, May, 1979 provide design guidance for standard gravity separators.

Based on an oil droplet size of 0.015 cm (150 microns), API design parameters typically meet the following conditions:

Maximum horizontal velocity:

$$V_h = 15V_r, \text{ or } 3 \text{ ft/min}$$

where V_r = rise velocity of design droplet

Separator depth: 3-8 ft

Separator width: 6-20 ft

Depth to width ratio: 0.3 to 0.8

Number of channels: greater than 1 if A_c
is greater than 160 ft,
where A_c = area of the channel

The API separator is designed for about 45 minutes of storage time, using a design temperature of 45-60 degrees F. Generally, operation at temperatures below the design temperature will decrease the efficiency of separation. Also, the higher the influent concentration, the easier it is to remove oil.

The above design will remove droplets down to about 150 microns in size. While this level of treatment is usually not adequate to meet the performance standard for oil and grease removal, use of an API separator may be appropriate as an intermediate process for pretreatment of oil and grease contaminated industrial wastewaters, or may be used in conjunction with site-specific conditions to provide BADCT.

Enhanced Gravity Separators

The size of a conventional gravity oil and water separator adequate for removal of oil droplets less than 150 microns often may be subject to space constraints or may become prohibitively expensive. In these situations, use of an enhanced gravity separator is required to meet discharge performance standards for oil and grease. Standard separators may be twice the cost and four times the size of a comparable enhanced separator.

Enhanced gravity separators use a variety of coalescing media. Most designs use long, relatively small-diameter cartridges stacked in parallel either horizontally, vertically, or at a 45-55 degree angle. If stacked horizontally or sloped, a laminar flow is created with the effective oil droplet rise height decreased and the collected oil directed to the separator surface for removal. Vertical stacking reduces free oil content by using oleophilic (oil-attracting) materials to attract and agglomerate oil droplets on the surface of the coalescing media. Enhanced gravity separators are designed for specific flow rates, the determination of which will vary depending on the actual design and the manufacturer's recommendations.

Other Design Elements

The design elements listed below are important for the efficient operation of standard and enhanced gravity oil and water separators.

Inlet conditions:

- Gravity flow introduced below the surface
- Inlet baffle to allow even distribution of influent
- Inlet piping sized for minimum pressure drop
- Inlet piping straight for at least 10 pipe diameters upstream
- Inlet piping with a minimum of elbows, tees, valves, and other fittings
- Pumps placed downstream of separator to prevent mechanical emulsification
- Removal of large quantities of particulates, if present, before entry into the separator
- Use of lowest ambient temperature of wastewater as the design temperature

Structural conditions:

- Most oil/water separators are constructed of fiberglass or steel. Underground separators constructed of steel should meet specifications of the Underwriters Laboratories, Subject UL-58 Standard for Steel Underground Tanks for Flammable and Combustible Liquids and Sti-P₃ for corrosion control.
- Separators should be leak tested before installation. An air test of the separator above ground should not exceed 5 pounds per square inch (PSIG) pressure while a soap solution is applied to seams.

Auxiliary equipment:

- Automatic control elements should meet NEMA standards
- Pumps for removing the oil layer should be self-priming and explosion proof.

Outlet conditions:

- Effluent piping must be designed with siphon breaks

Operation & Maintenance

Waste Handling

Separated oil may be withdrawn from the unit using:

- Adjustable skimmers, such as rotating drum, belt-type, and adjustable baffles
- Automatic pumpout systems
- Level sensing systems to signal manual pumpout.

Storage and disposal of waste oil must meet all applicable regulations

Maintenance

Separators should be inspected periodically for general maintenance and removal of accumulated sedimentation.

- Manual pumpout systems require inspection to determine the need for containment pumpout. At the time of pumpout, foreign debris should be removed from the separator baffle plate area.
- Automatic pumpout systems should be checked for level control. The pump suction and discharge pressures should be inspected periodically using a pressure gauge.
- Horizontal plate separators require constant maintenance because of the build-up of sediment on the top side of the plates.
- Inclined plate separators are prone to silting at the bottom. Plates must be removed for pressure washing.

Manufacturer's maintenance recommendations should be incorporated into a routine operation and maintenance inspection schedule.

Spill Capacity

The additional capacity needed to contain spills for those oil/water separators located in areas where spills may occur should be equal to the total volume of the spill. For example, if the normal oil storage capacity of a separator is 43% of a total volume of 1000 gallons, and the manufacturer has designed the unit to provide an emergency oil storage capacity of 80% of the total volume, then the expected spill volume should be no greater than 370 gallons. For spills occurring during fluid transfer, the spill volume may be assumed to equal the fluid transfer rate in gallons per minute times two minutes.

Some manufacturers provide an oil stop valve, which allows flow through of water, but closes if surrounded by oil. This design component is recommended for separators located in potential spill areas.

In most circumstances, above ground storage facilities located within the drainage area boundaries of the oil/water separator should not rely on the oil/water separator to provide spill volume, but, rather, should provide secondary containment systems which are designed, installed, and operated to prevent any migration of accumulated liquids out of the system to the soil, groundwater, or surface water at any time during the use of the storage structure.

NOTE: Oil/water separators which may receive drainage containing contaminants other than petroleum hydrocarbons may require additional discharge control measures.

Pollution Prevention Plan

The Pollution Prevention Plan should include appropriate information under the following headings:

Site Evaluation

- A list of each wastewater source and a diagram indicating the location in the drainage system of influent wastewater streams.
- A description of industrial activities occurring in each drainage area
- An inventory of materials that may be present in the wastewater
- A history of leaks or spills for the last three years

Best Management Practices

- Housekeeping practices used to minimize introduction of contaminants into wastewater or stormwater
- Preventative maintenance of facility equipment affecting discharge
- Spill prevention and response procedures
- Employee training and record keeping

ATTACHMENT 1. Processes for Oil and Grease Removal

Process	Description	Advantages	Disadvantages
Gravity separation	API,CPI, TPS, PPI	Removal of suspended solids, and free and dispersed oils; simple and economical operation	No removal of oil droplets < 20µm or soluble oil; limited removal of emulsified oil Requires relatively low flow or large tank
Air Flotation	DAF,IAF	Removal of suspended solids; can remove emulsified and dispersed oils with chemical addition; effectively treats shock loads	Chemical sludge handling required when chemical coagulants used
Chemical flocculation	Used with gravity separation and air flotation	Treatment/removal of high levels of suspended solids	Chemical sludge produced
Filtration	Sand, anthracite, multimedia, crushed graphite, oleophically coated ceramic, hollow fiber membrane cartridge (ultrafiltration)	Removal of suspended solids; separation of free, dispersed and emulsified oil	Backwashing, which requires subsequent treatment
Coalescence	Fibrous membrane	Effective removal of all oil components, except soluble oils	Extensive pretreatment; high potential for fouling; not practical for full-scale operation
Membrane process	Reverse osmosis; ultrafiltration; hyper filtration	Removal of soluble oil	Membrane fouling and limited life; extensive pretreatment; low flux rate; not practical for full-scale operation
Biological processes	Activated sludge	Effective soluble oil removal	Extensive pretreatment required to reduce influent oil levels to < 40 mg/l
Carbon adsorption	GAC used for filtration and coalescing separator; PAC used for removal of soluble oils only	Effective removal of all oil components including soluble oils	Expensive; extensive pretreatment; carbon must be regenerated or replaced; not practical for full-scale operation

Reference: Corbi H., R.A. Handbook of Environmental Engineering.
McGraw-Hill Publishing Co. 1990. Table 682

ATTACHMENT 2. Calculation of Stormwater Flow Rate

In the case of stormwater, the flow rate calculation is based on a 10 year storm event with a 2 hour duration. The Rational formula is used to determine the total flow volume from the area drained. The Rational formula is:

$Q = CiA$ where
Q = the rate of runoff from an area
C = the runoff coefficient
i = rainfall intensity, and
A = the area of the drainage basin

The following method for flow rate calculations is adapted from Chapter 2 of EPA Publication 832/R-92/005, " Storm Water Management for Construction Activities--Developing Pollution Prevention Plans and Best Management Practices".

- (1) Delineate drainage boundaries on topographic map, or use drawings with arrows showing direction of drainage. Either method should indicate any major drainage control structures present, such as swales or channels.
- (2) Estimate the total drainage area. For drainage areas which encompass the entire site, legal documents such as deeds or property surveys are acceptable. For drainage areas covering only of a portion of the total site, use a scaled site map and planimeter or a scaled site map and grid paper, as described below:
 1. Place the graph or grid paper over the scale drawing and trace the outline of the drainage area, including the any off-site water draining onto the property.
 2. Count the total number of complete squares within the site area, count every two partial squares along the edges of the site as one square.
 3. Divide the total number of squares by the number of squares on one square inch of graph/grid paper. This results in the number of square inches contained in the outline of the site.
 4. Multiply the result of Step 3 by the number of square feet in one inch square based on the scale of the drawing. This results in the number of square feet on the site.
 5. Divide the number of square feet on the site by 43,560 square feet per acre to determine the number of acres.
- (3) Calculate the runoff coefficient. Generally, the less rainfall that infiltrates into the ground, evaporates, or is otherwise absorbed on site, the higher the runoff coefficient. Runoff coefficients are shown in Table 2.

When a drainage area has more than one type of surface material with more than one runoff coefficient a "weighted C" must be calculated, as follows:

$$C = \frac{A_1C_1 + A_2C_2 \dots + A_xC_x}{\text{Sum of A}}$$

where A = acres and C = coefficient.

- (4) An acceptable value for the 2-hour, 10 year storm intensity for the Phoenix area is 0.17 inches. For other areas, this value may be obtained from the local flood control district, the Soil Conservation Service, the National Weather Service, or may be determined using the methods outlined in the Arizona Department of Transportation (ADOT) manual, "Hydrologic Design for Highway Drainage in Arizona".

ATTACHMENT 2. TYPICAL "C" VALUES (ASCE 1960)

Description of Area	Runoff Coefficients
Business	
Downtown areas	0.70-0.95
Neighborhood areas	0.50-0.70
Residential	
Single-family area	0.30-0.50
Multi units, detached	0.40-0.60
Multiunits, attached	0.60-0.75
Residential (suburban)	0.25-0.40
Apartment dwelling areas	0.50-0.70
Industrial	
Light areas	0.50-0.80
Heavy areas	0.60-0.90
Parks, cemeteries	0.10-0.25
Playgrounds	0.20-0.35
Railroad yards	0.20-0.40
Unimproved areas	0.10-0.30
Streets	
Asphalt	0.70-0.95
Concrete	0.80-0.95
Brick	0.70-0.85
Drives and walks	0.75-0.85
Roofs	0.75-0.95
Lawns - coarse textured soil (greater than 85% sand)	
Slope: Flat, 2%	0.05-0.10
Average, 2-7%	0.10-0.15
Steep, 7%	0.15-0.20
Lawns - fine textured soil (greater than 40% clay)	
Slope: Flat, 2%	0.13-0.17
Average, 2-7%	0.18-0.22
Steep, 7%	0.25-0.35

REFERENCE: Corbitt, R. A. Handbook of Environmental Engineering.
McGraw-Hill Publishing Co. 1990. Table 682

ATTACHMENT 3. Stokes Law

$$V_R = \frac{G(S.G.p - S.G.f)D_p^2}{8n}$$

V_R = velocity of rising or settling particle, cm/sec

G = gravitational constant, 980 cm/sec²

$S.G.p$ = specific gravity of the particle, gm/cm³

$S.G.f$ = specific gravity of the continuous fluid, gm/cm³

D_p = diameter of the particle, cm

n = viscosity of the continuous fluid, poise

To convert cm/sec to in/sec, multiply by 0.3937